

**Remarks/Arguments**

Claims 1 – 34, all of the original claims as filed, are cancelled, and new claims 35 – 49 added. Claims 1 – 10 were the only claims remaining from those originally presented because of restriction requirements by the Examiner. Applicants respectfully reserve the right to submit claims 11 – 34 in subsequent divisional and/or continuation applications.

New claim 35 includes many additional limitations over originally presented claim 1. Support for these newly added limitations is provided below to assist the Examiner:

<u>Limitation:</u>	<u>Support (Specification):</u>
filler particles: 200 Angstroms- 35 microns	page 14, lines 19 and 20
particles 10-80 % by volume of the dielectric layer	page 14, lines 17 and 18
thru hole density: 5,000 to 10,000 per square inch	page 16, lines 21 – 23
dielectric constant: 3.4 – 4.0	page 16, line 5

Support for added limitations in subsequent dependent claims is as follows:

<u>Limitation:</u>	<u>Support:</u>
high Tg, DICY free epoxy resin (claim 36)	page 13, lines 26 – 28
added thermoplastic resin (claim 37)	page 13, last line – page 14, line 1
filler 39% by volume (claim 38)	page 14, line 19
thru hole aspect ratio (claim 39)	previous claim 2
spherical amorphous silica particles (claim 40)	page 14, lines 1 and 2

aluminum oxide or aluminum nitride

particles (claim 41)

page 14, lines 26 and 27

coupling agent – few monolayers (claim 42)

page 15, lines 1 – 6

coupling agent –silane (claim 43)

page 15, lines 1 – 3

thixotrope added to layer (claim 44)

page 14, line 6

The limitations of claim 45 – 49 are found in previous claims 5 – 9.

Support being provided for all of the limitations found in the claims presented herewith, these limitations do not constitute the addition of new matter. Entry is urged.

The invention now defined by new independent claim 35 involves a dielectric layer for the claimed circuitized substrate which is comprised of a composition including the unique combination of an *epoxy* resin and a filler having particles of only 200 Angstroms to 35 microns in size, which particles, significantly, comprise from as low as 10 percent to as high as 80 percent by volume of the dielectric layer in which these are located (with the epoxy resin). This unique combination of an *epoxy* resin and *filler* assures that a very high density thru hole pattern (5,000 to 10,000 per square inch of the layer) may be formed therein and which may provide necessary electrical couplings in the formed product, which, of further significance, possesses a highly desirable relatively low dielectric constant as low as about 3.5 to about 4.0. Most significantly, all of this is attainable without the need for supporting material which includes continuous or semi-continuous fibers as part of the dielectric layer. Such fibers are specifically excluded in sole independent claim 35. Thus, Applicants have taught a new and unique dielectric layer which is ideally suited for use as part of circuitized substrates such as chip carriers and printed circuit boards without the need for fiber-glass additives or the like as has been essential in dielectric compositions including resins, *especially epoxy-type resins*. The combination of using an epoxy resin with filler particles of the type taught herein and in the percentages taught herein, in combination further with those

particles of a defined small size and predetermined percentage by volume is indeed considered a significant advancement in the art. None of the documents of record in this application teach or suggest this unique combination.

Regarding the dependent claims, Applicants further define the epoxy resin (claim 36) as being a high glass transition temperature ( $T_g$ ) and dicyandiamide (DICY)-free epoxy resin, as supported at page 13, lines 26 – 28.  $T_g$  is a well-recognized symbol for glass transition temperature in such materials, with one citation found at [http://en.wikipedia.org/wiki/Glass\\_transition\\_temperature](http://en.wikipedia.org/wiki/Glass_transition_temperature). Further description of the well-known term dicyandiamide is provided at: <http://www.chemicalland21.com/arokorhi/specialtychem/finechem/DICYANDIAMIDE.htm>.

Excerpts from both of these sites are attached as **Exhibits A** and **B**, respectively. Failing to teach or suggest the invention of previous claim 35, the documents of record inherently are incapable of suggesting this more detailed description of one of the key elements of the claimed combination. The use of such a particular *epoxy* in the claimed combination is deemed especially unobvious.

Applicants have also taught a new dielectric composition as defined above which further includes a *second resin*, this of the thermoplastic variety (claim 37). This unique combination affords the resulting dielectric the added highly desirable features of greater toughness and coating flake-off resistance (page 14, line 1). Such a combination of two resins and the filler characteristics to assure a dielectric layer which does not require continuous fibers, semi-continuous fibers or the like as part thereof is truly unobvious, especially when considering that none of the documents of record herein remotely suggest such a combination..

Attention is particularly drawn to dependent claim 39. The specific teaching of such a high density pattern of thru holes (5,000 – 10,000 per square inch) as earlier claimed in combination with holes of such small size relative to the thickness of the substrate in which these are so tightly positioned is certainly unobvious. The documents of record fail to suggest such a high concentration of thru holes, let alone same within a resin-filler dielectric layer excluding supporting fiber elements.

The use of filler particles which include a coupling agent thereon having a thickness of no more than a few monolayers (claim 42) is also especially unobvious because none of the documents of record remotely suggest using such an agent, and particularly the chosen one (silane – claim 43) in such a capacity in an epoxy resin-filler composition. As Applicants have taught, the addition of but a few monolayers of this agent on the particles provides increased reinforcement for the final layer compared to particles not so treated. In like manner, the use of a thixotrope (claim 44) in the manner taught herein (to provide improved balance between solution viscosity and the melt viscosity – page 14, lines 6 – 10) adds further to the unobvious argument, again, considering that none of the documents suggest such an addition to the unique combination claimed.

Applicants must also submit that the invention defined by dependent claim 47 is certainly unobvious to one of ordinary skill in the art. This unique teaching, of using a high concentration of thru holes within a dielectric layer comprised of the combination of elements taught (especially the addition of fillers with particles) to interconnect opposed conductive layers on opposite sides of the dielectric is unobvious. One skilled in the art would never think to couple such layers through an interim dielectric with such elements therein in the concentrations taught and at the extremely high-density pattern thereof. 5,000 – 10,000 holes per square inch of the layer is such a relatively high number to one of such skill that he/she would certainly attempt an alternative means of accomplishing such delicate connections, assume he/she were able to think of any means whatsoever!

The invention as now claimed is deemed patentable over the documents of record herein, including particularly **Bindra** (5,229,550), **Mao** (2004/0256731) and **Bhatt** (5,822,856) cited by the Examiner. The rejections under both 35 USC 102 and 103 based on these documents are thus overcome and withdrawal thereof is urged. **Bindra** is particularly noteworthy. As the Examiner properly notes, **Bindra** does discuss at column 2, lines 13 – 26, the use of PTFE and CTFE fluorocarbons for dielectric materials, and the possibility of using fillers such as quartz and silicon. However, nowhere does **Bindra** appear to suggest *epoxy* resin in combination with fillers as taught by Applicants, where the resulting structure is devoid of fibers. Further, Applicants must argue that **Bindra** must be considered as a whole. When doing so, Applicants are quick to assert that **Bindra** equally suggests the addition of fibers (col. 2, line 19) by teaching the addition of “woven fluorocarbon fabric”, which would most likely result in the formation of loose ends of fiber-like material in the dielectric. **Bindra** thus fails to suggest the instantly claimed invention and in fact, appears to teach away from same.

**Mao** is likewise deficient in teaching or suggesting the claimed invention. Nowhere does this document specifically mention excluding fibers in the final composition. Admittedly, **Mao** does not recite the use of such fibers, but, as Applicants have argued extensively in their Background, the person of ordinary skill in the art is likely to use supporting fibers (e.g., from fiberglass cloth) when employing resins and the like for dielectric materials, especially epoxy-based resins. If **Mao** is able to form a dielectric sans such fiber, it must be argued he is unable to form the high-density pattern of thru holes as taught by Applicants. Interestingly, nowhere does **Mao** describe such a concentration. **Mao** thus fails to suggest the instantly claimed invention.

**Bhatt**, cited secondarily by the Examiner as part of the 35 USC 103 rejection, appears more concerned with forcing conductive paste (he calls “filler”) into already formed openings within his dielectric. Regarding the particular dielectric, one example **Bhatt** recites is “an organic substrate (e.g. epoxy) preferably filled with axially stiff fibers (fiberglass or polyaramide

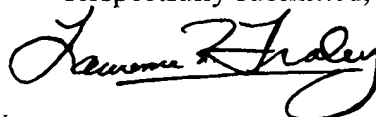
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Amdt. dated 12/20/05  
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fibers)” (second sentence under Best Mode). Thus, Bhatt, like others of skill in the art, utilizes fibers (in **Bhatt’s** case, axially stiff fiberglass or polyaramide) when using *epoxy* dielectric resins. Bhatt thereby supports Applicants’ Background conclusions.

Applicant respectfully submits that the claims presented herewith are patentably distinguishable over the documents of record herein, particularly those cited in the 10/31/2005 Office Action, and that the rejections applied in said Office Action have been fully overcome.

Accordingly, Applicant requests that a timely Notice of Allowance be issued in this Application. Should the Examiner believe that differences remain which, if overcome, would result in allowance of the Application and that said differences can be discussed in a phone conversation, the Examiner is respectfully requested to phone the undersigned, at the number below, for the purpose of discussing said differences and obtaining an allowance for this Application.

Respectfully submitted,



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## **EXHIBIT A.**

### **Glass Transition Temperature:**

A simplistic view of a material's **glass transition temperature** ( $T_g$ ) is the temperature below which molecules have very little mobility. For polymers, physically, this means that on a larger scale, they are rigid and brittle; the polymer is a glass. Above the glass transition temperature the polymer becomes rubbery and is capable of larger elastic or plastic deformation without fracture, due to the breaking of the secondary bonds. The  $T_g$  is usually applicable to amorphous phases and is commonly applicable to glasses and plastics.

Consider a molecular liquid, which is cooling slowly down. At certain temperature the kinetic energy of molecules no longer surpasses the binding energy between neighboring molecules and growth of organized solid matter, a crystal, begins. Formation of an ordered system takes certain amount of time since molecules must move from their current location to energetically preferred point at crystal nodes. As temperature falls molecular motion slows further down and if cooling rate is fast enough molecules never reach their destination - the substance enters into dynamic arrest and disordered solid - a glass forms. Such arrest apparently takes place at certain temperature, which is called the glass transition temperature,  $T_g$ . Needless to say  $T_g$  is cooling rate dependent as is the glass so formed.

A full discussion of  $T_g$  requires an understanding of mechanical loss mechanisms (vibrational and resonance modes) of specific (usually common in a given material) functional groups and molecular arrangements. Factors such as heat treatment and molecular re-arrangement, vacancies, induced strain and other factors affecting the condition of a material may have an effect on  $T_g$  ranging from the subtle to the dramatic.  $T_g$  is dependent on the viscoelastic materials properties, and so varies with rate of applied load (silly putty is a good example of this, as is stiff corn flour/water mixtures - pull slowly and they flow, pull rapidly and they shatter).

In polymers,  $T_g$  is often expressed as the temperature at which the Gibbs free energy is such that the activation energy for the cooperative movement of 50 or so elements of the polymer is exceeded. This allows molecular chains to slide past each other when a force is applied. From this definition, we can see that the introduction of side chains and relatively stiff chemical groups (such as benzene rings) will interfere with the flowing process and hence increase  $T_g$ . With thermoplastics, the stiffness of the material will drop due to this effect. This is shown in the figure below. It can be seen that when the glass temperature has been reached, the stiffness stays the same for a while, till the material melts. This region is called the rubber-plateau.

$T_g$  can be significantly decreased by addition of plasticizers into the polymer matrix. Smaller molecules of plasticizer embed themselves between the polymer chains, space them apart (increasing the free volume) and allow them to move against each other easier.

In glasses (including amorphous metals and gels),  $T_g$  is related to the energy required to break and re-form covalent bonds in a somewhat less than perfect (may be regarded as an understatement) 3D lattice of covalent bonds. The  $T_g$  is therefore influenced by the chemistry of the glass. Eg. add B, Na, K or Ca to a silica glass, which have a valency less than 4 and they help break up the 3D lattice and reduce the  $T_g$ . Add P which has a valency of 5 and it helps re-establish the 3D lattice, increasing  $T_g$ .



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**EXHIBIT B.**

Dicyandiamide, also called cyanoguanidine, is used in the production of wide range of organic chemicals including slowly and continuous nitrogen release fertilizers; fire proofing agent; **epoxy laminates for circuit boards**, powder coatings and adhesives; water treatment chemicals; dye fixing, leather and rubber chemicals; explosives; pharmaceuticals;

white crystalline powder  
99.5% min  
208-212 C  
0.5% max  
0.3% max  
300ppm max

25kgs in bag, 19mts in a container

N/A

European Hazard Symbols: XN, Risk Phrases: 20/21/21, Safety Phrases: 24/25

Cyanamide, the amide of normal cyanic acid, is a white crystals melting at 45 C; readily soluble in water, alcohol and ether. It is prepared by the desulphurization of thiourea in the presence of catalyst (mercuric oxide) or by the action of ammonia with cyanogen halides. It polymerizes to dicyandiamide when heated over 150 C and to tricyantriamide as well as to melamine. Its metal salt especially calcium cyanamide is an environmentally friendly multi-purpose fertilizer to supply nitrogen and lime to plants and soil. Cyanamide is used in fertilizer, defoliant and weed killer. It is used as a raw material of melamine, dicyandiamine, thiourea and other guanidines.